

Chapter 5 Rehabilitation and Modification of Dams

5-1. Dam Safety Rehabilitation

Rehabilitation or modification of Corps of Engineers dams for safety purposes is accomplished through the Major Rehabilitation Program and the Dam Safety Assurance Program.

5-2. Major Rehabilitation Program

The Major Rehabilitation Program is to allow accomplishment of significant, costly, one-time structural rehabilitation or major replacement work (other repairs related to dam safety are accomplished under the normal Operation and Maintenance program). The work under this program restores the project to its original condition to serve as originally intended. An example of dam safety work under this program would be the installation of a "cut-off" wall to control seepage through a dam. Projects approved for major rehabilitation require budget justification and other supporting data similar to the budget information prepared for construction projects. The Major Rehabilitation Program is limited to the major repair or restoration of main structures such as dams, locks, and powerhouses, exclusive of electrical, mechanical, and other equipment, except that such equipment may be included where it is essential to and integral with the feature of the project being rehabilitated. The Major Rehabilitation Program is not applicable to local protection projects, dams, or other works turned over to local interests for operation, maintenance, and major replacement (U.S. Army Corps of Engineers, Office of the Chief of Engineers 1977; ER 1130-2-500; Federal Emergency Management Agency 1992b; Wiseman 1987).

5-3. Dam Safety Assurance Program

a. General. The Dam Safety Assurance Program provides for modification of completed Corps of Engineers dam projects which are potential safety hazards in light of current engineering standards and criteria. This program is one part of the Corps'

numerous dam safety activities. The problems generally fall into two categories: hydrologic and seismic. The program is intended to facilitate upgrading of those project features which have design or construction deficiencies related to dam safety in order to permit the project to function effectively and as originally intended. In order to qualify, the modifications must be within the Chief of Engineers' discretionary authority and also must be such that they cannot be accomplished under routine maintenance. Projects approved for Dam Safety Assurance will require budget justification and other supporting data similar to the budget information prepared for construction projects. The Dam Safety Assurance Program may also be used to modify dams built by the Corps of Engineers and turned over to local interests to operate, maintain, replace, rehabilitate, and repair (ER 1130-2-419, ER 1165-2-119, ER 1110-2-1155, Walz 1990a).

b. Policy on hydrologic criteria. Since the Corps of Engineers began building dams, the policy has been that failure of a Corps of Engineers dam should not significantly increase the downstream hazard over the hazard which would have existed if the dam had not failed. However, new policy requires more analysis and documentation from the field offices when recommending improvements to hydrologically deficient dams (Duscha 1986). Additional background information on hydrologic criteria is available (National Research Council 1985; Federal Emergency Management Agency 1986a, 1986c; Wiseman 1987; Lave, Resendiz-Carrillo, and McMichael 1990; Task Committee on Spillway Design Flood Selection, Committee on Surface Water Hydrology, Hydraulics Division, American Society of Civil Engineers 1988). The following policy is used to make decisions on the merits of dam safety modifications to meet current hydrologic criteria given in ER 1110-8-2(FR) (ER 1110-2-1155).

(1) Planning for a dam safety modification will consider combination of structural design modifications as well as nonstructural measures, including downstream actions and changes in water control plans. The recommended plan should be for the dam safety modification which meets or exceeds the base safety condition (BSC). The BSC will be met when a dam failure related to hydrologic capacity will result in no significant increase in downstream hazard

(loss of life and economic damages) over the hazard which would have existed if the dam had not failed. Recommendations for any modifications that would accommodate floods larger than the flood identified as the BSC must be supported by an analysis that presents the incremental costs and benefits of the enhanced design in a manner that demonstrates the merits of the recommendation. Such enlargement of project scope may require Congressional authorization.

(2) Determination of the flood that identifies the BSC will require definition of the relationship between flood flows and adverse impacts (loss of life and economic damages) with and without dam failure for a range of floods that fully utilizes the existing structure up to the probable maximum flood (PMF). Selection of a BSC predicated on the hazard to life from dam failure will require supporting information to demonstrate that the safety of the population would actually be threatened. The evaluation should distinguish between total population downstream of a dam and the population that would likely be in a life threatening situation given the extent of prefailure flooding, warning time available, evacuation opportunities, and other factors that might affect the occupancy of the incrementally inundated area at the time the failure occurs. Appropriate freeboard necessary to accommodate potential wind and wave conditions will be included for all flood evaluations. The evaluation consists of two phases. Phase I is a comparative hazard analysis in which the threshold flood and the BSC are established. Phase II is the risk-cost analysis required if modifications for a flood larger than the BSC is recommended (ER 1110-2-1155). Examples of the analysis required to develop the base condition are illustrated in "Guidelines for Evaluating Modifications of Existing Dams Related to Hydrologic Deficiencies," Institute for Water Resources Report 86-R-7 (Stakhiv and Moser 1986).

(3) Selection of a recommended level of modification also should reflect concern for economy. Modification costs in the vicinity of the scale of improvement identified as the BSC should be examined for sudden increases in the cost/scale of improvement relationship. This type of change could occur, for instance, when a costly highway relocation is encountered near the scale of improvement identified as the BSC. An adjustment in the level of fix recommended may be warranted under these conditions. On the other hand, the large increase in costs may be justified if a

significant reduction in the hazard, with and without dam failure, is achieved.

(4) Measures to accommodate floods larger than the BSC may be warranted in some cases. When the project benefits that would be lost, and repair costs for failure are large enough, costs for structural modifications to prevent failure may be economically justified in spite of the low probability of the floods involved.

(5) Conduct of the analysis requires careful application of professional judgment for determining those parameters where data and modeling capability are limited. Therefore, the importance of documenting the logic assumptions, critical to the conclusions and recommendations drawn from the analysis, cannot be over-emphasized. Also, the evaluation should produce a significant amount of information needed throughout the decision making process, particularly in those cases where it is appropriate to proceed beyond the base condition. The information must be displayed in a format that assists the decision maker when evaluating the important trade-offs involved.

c. *Policy on seismic criteria.* The following policy is used to make decisions on the merits of dam safety modifications related to current earthquake design criteria (ER 1110-2-1155).

(1) Projects that retain or have the potential to retain a permanent pool, failure of which would result in loss of life, substantial property damage, or indirect loss such as the loss of essential emergency services provided by the dam, are required to survive and remain safe during and following the maximum credible earthquake event. Such projects shall additionally be capable of remaining operational with only minor repair during and after an operating basis earthquake (OBE). In the case of projects intended for short-term temporary flood storage, including those with low permanent pools, risk based assessments may be warranted. Combining a rare earthquake event with a rare hydrologic event demonstrates extremely low risk and therefore unwise use of funds.

(2) Technical requirements for selecting seismic design values and performing design analyses are contained in ER 1110-2-1806 (see also Federal

Emergency Management Agency 1985b). These criteria,

along with current state-of-the-art techniques, are intended to be used in such studies and analyses. Criteria levels, safety factors, and design methods are the same as that for new projects.

(3) Since judgment of ground motion parameters for design is based on geologic and seismic history, future strong seismic events may raise the design values against which stability should be analyzed. Should such a situation occur, the district, if convinced that the ground motion parameters have changed significantly enough to affect the safety of the project, shall prepare an evaluation report as detailed in paragraph 5-4.a.

(4) Strong motion accelerometers that have been placed on or around Corps dams are intended as a check on the design seismic resistance of the structure. If these instruments record ground motion parameters that, after analysis, are found to be below the values used in design but yet the structure received damage, a letter report (in the case of no expected future remedial action) or an evaluation report (in the case of anticipated remedial action) shall be written describing the situation and containing the district's recommendation.

(5) Seismic stability of auxiliary structures and devices, such as regulating outlet towers, spillway gates, retaining walls, hydraulic equipment, and electric lines, shall be upgraded where necessary to provide for dam safety, including requirements for dams to remain operational following the OBE. Auxiliary structures that do not affect dam safety or operational safety shall be judged for modification on economic or other grounds rather than dam safety.

(6) Seismic stability assessment for dam safety may also involve reservoir rim slides, effects of dam overtopping, movements of critical retaining walls, foundation or abutment changes, susceptibility of embankment dams to liquefaction, or any other feature that might contribute to dam failure.

5-4. Procedural Requirements

In order to identify and process work for inclusion in the Dam Safety Assurance Program, reporting and

design procedures given in ER 1110-2-1155 will be followed.

a. Dam Safety Assurance Evaluation Report. A reconnaissance will be conducted and a report prepared covering preliminary evaluation of work items considered necessary to upgrade the project. Format and content of the evaluation report will follow the requirements given in Appendix C of ER 1110-2-1155. Detailed field investigations and office studies will be kept to a minimum. The report will be designed to develop a basis for decision on:

(1) The need for and justification of the modification for dam safety.

(2) The appropriateness of funding under the Dam Safety Assurance Program.

(3) Whether the work requires additional authorization.

(4) Whether the work is subject to cost-sharing and identification and the views of the cost sharing partner.

(5) The scope and cost of subsequent investigations.

(6) The scope and cost of design requirements.

(7) The estimated cost for construction.

If a determination on whether a problem exists cannot be made during the preparation of the evaluation report, then the need for special engineering investigation(s) will be identified and justified in the report. In those instances where there is need for both a special engineering investigation and follow-on investigations of known problems, both will be identified in the report. In addition, a plan of study and cost estimate for the special engineering investigation(s) will be included. Special engineering investigations are those extensive and complex investigations that may be required to determine the need for and/or scope of remedial construction. Special investigations include hydraulic modeling and geological and seismic investigations.

b. Design memorandum. For major dam safety modifications, a DM is usually prepared following approval of the evaluation report and any special investigations. Content of the DM will follow the requirements given in Appendix D of ER 1110-2-1155. The initial DM will present the results of the evaluation report and any special engineering investigations and make final recommendations concerning the need for and/or scope of the proposed modification. Included with this recommendation will be the estimated cost, schedule for construction, and design of the approved plan. This will provide the basis for preparation of plans and specifications.